Policy Research
WORKING PAPERS
Public Economics

Country Economics Department
The World Bank
April 1992
WPS 887

Power Sharing and Pollution Control

Coordinating Policies Among Levels of Government

William Jack

Most policy decisions about targets and instruments of pollution control should probably be made at the highest level of government involved. But effective implementation — including inspection, enforcement, and prosecution — may require involving all levels of government. Coordination is then necessary, with substantive implications for choices of policy tools and the assignment of responsibilities.

Policy Research

WORKING PAPERS

Public Economics

WPS 887

This paper — a product of the Public Economics Division, Country Economics Department — is part of CECPE's work program on evaluating economic policy instruments for pollution control, and part of the research project "Pollution and the Choice of Economic Policy Instruments in Developing Countries" (RPO 676-48), funded by the Bank's Research Support Budget. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Peggy Pender, room N10-067, extension 37851 (April 1992, 53 pages).

Traditional approaches to pollution control emphasize the "government's" role in providing incentives to alter the behavior of relevant economic agents. But to exploit cost advantages at different levels of government, pollution control policies typically involve assigning a variety of responsibilities to different public agencies.

These responsibilities can include choosing policy targets, controlling instruments, and developing and implementing strategies for monitoring and enforcement.

A hierarchically decentralized management structure introduces problems of coordination because different agencies may have different objectives. These problems can be alleviated — and the efficiency gains from decentralized control retained — by modifying intergovernmental relations, particularly by using implicit and explicit financial transfers and by dividing initial property rights equally among local authorities to ensure that they will all want to participate in the negotiating process Jack describes in this paper. Among Jack's conclusions:

- No single level of government should be responsible for all environmental policy. Policy decisions about targets and instruments should be based on the most complete and accurate data available and should encompass all aspects of the problem. But effective implementation — including inspection, enforcement, and prosecution — may require involving all levels of government.

- Coordination of government policies — between levels of government (vertical coordination) or between administrative bodies in the same tier (horizontal) — may be improved by using intergovernmental incentive schemes.

- One device is to grant the local government financial autonomy, in the sense that any taxes or fines it collects from enforcement are retained locally. There are substantive implications in the choice of control instrument. For example, if local governments maximize revenue and an emission *tax* is used, firms with high costs of abatement could be forced to bear most of the cost of reducing emissions. It may be more efficient for the local government to enforce a *standard*, because then most abatement is carried out by low-cost abaters.

- A more subtle incentive is to explicitly affect the enforcement budget of a local regulator. By controlling the size of the budget through lump-sum transfers, and indirectly through fine rebates, the central government can modify the inspection activities of a local regulatory agency in a way that improves welfare.

- Under decentralized control, command and control policies may be implemented more efficiently than market-based instruments. And uniform national or regional standards may improve the efficiency of interjurisdictional negotiations.

Table of Contents

Power Sharing and Pollution Control:

Coordinating Policies Among Levels of Government

1. INTRODUCTION 1

2. THE ASSIGNMENT PROBLEM 3

(i) What is to be assigned? 3
(ii) Formulating the assignment choice 4
(iii) Intergovernmental incentives 7

3. VERTICAL COORDINATION 11

(i) Incentive schemes 11
(ii) Local governments as residual claimants 14
(iii) The enforcement budget as a control device 17
(iv) Comparative incentive schemes and enforcement 19

(a) Inter-jurisdictional Regulatory Competition 20
(b) Inter-temporal Comparisons 21
(c) Using Firm Behavior to Monitor Regulatory Activity 22

(v) Summary 23

4. HORIZONTAL COORDINATION 23

(i) Environmental spillovers, negotiations, and property rights 24

Distributional Issues: A Caveat 32

(ii) Inter-ministerial coordination 33
(iii) Summary 35

5. CONCLUSIONS AND POLICY IMPLICATIONS 36

BIBILOGRAPHY 39

APPENDIX 1 44
APPENDIX 2 51

Many thanks to Shanta Devarajan, Gunnar S. Eskeland, Antonio Estache, Emmanuel Jimenez, Jeni Klugman, Jeremy Bulow, Andre Fargeix, and Frederik van Bolhuis for help and comments. This paper is part of CECPE's work program on evaluating economic policy instruments for pollution control, funded by RPO 676-48.

1. INTRODUCTION

Traditional approaches to pollution control emphasize the role of "the government" in providing appropriate incentives to alter the behavior of the relevant economic agents. The choice of control strategy, for instance economic instruments versus regulation, is usually analyzed within a simple regulatory structure, involving the government and the polluting and/or polluted agents.

The choice is determined, inter alia, by the objectives of the government, the nature and accuracy of information, the enforceability of policies, political feasibility, and financial and institutional constraints.[1] Some of these factors can be especially important in developing countries, where information and monitoring systems are weak, and public finances often severely constrained.

The strength of the constraints frustrating effective environmental policy design may, however, depend on the government body involved. Different levels of government can be expected to fulfill the various requirements of an overall control mechanism at different costs. Based on this observation, an optimal pollution control policy will consist of a particular assignment of responsibilities across government agencies, minimizing the total associated costs. This assignment choice may be stated simply as:

(i) who sets environmental objectives and targets?;

(ii) who chooses the instruments (e.g.taxes, quotas)?; and

(iii) who implements the control strategy?

The solution to this assignment problem will clearly depend upon the country and pollution problem. Nonetheless, if all government agencies pursue the same objectives, the solution is in theory, straightforward: each function should be assigned to the agency with a comparative advantage in that area.

---

[1]See Eskeland and Jimenez (1991), for a review of the instrument choice problem in developing countries.

This last assumption, however, is unlikely to be fulfilled. In general, when government agencies have different objectives, any diversified assignment of responsibilities will introduce additional constraints. These incentive constraints, resulting from the need to explicitly coordinate the actions of the different government agencies involved, can be significant.

One solution to this problem is to recentralize the control strategy. With a single government agency making all relevant decisions no inter-governmental coordination problems arise. However such a concentration of responsibilities, while avoiding the incentive costs, can result in high information and transaction costs.

A preferable approach is to search for alternative means by which the actions of government agencies can be coordinated. For instance, if conditional inter-governmental transfers are possible, incentives at lower levels can be suitably modified. More generally, by modifying the interactions of government agencies, policy coordination can be improved. This paper aims to identify the important features of inter-governmental and government-polluter relationships, their influences on the choice of control strategy, and ways in which they can be modified to yield improved policy performance.

The next section describes the assignment problem in detail. Section 3 addresses vertical co-ordination - that is, mechanisms by which the actions of government agencies at different levels can be coordinated. Particular attention is given to the problem of inducing efficient monitoring and enforcement of national policies at the local level.

Section 4 considers the coordination of horizontally related agencies. The primary concern is with inter-jurisdictional externalities, and the coordination of local municipal policies: should local governments be allowed to set their own emission control policies, or are uniform national standards preferred?. At the central government level, the horizontal problem of inter-ministerial coordination is also considered. Finally, Section 5 presents conclusions and general lessons for the design of pollution control policies.

2. THE ASSIGNMENT PROBLEM

We have suggested that an effective environmental policy may require the assignment of a number of responsibilities to different levels of government. In this section we present a conceptual framework within which to think about the following questions:

(i) What is to be assigned?; and

(ii) How should the assignment choice be formulated operationally?

These issues will be considered in the following two sub-sections It will be seen that an important factor is the coordination of the actions of different government bodies, and that the assignment of responsibilities should not be made without explicitly accounting for possible coordination failures. The inclusion of such problems in the decision process may lead to either a change in the assignment -- for instance, favoring quantity controls ahead of price mechanisms -- a modification of inter-governmental relations -- such as forcing local monitoring agencies to finance a part of their enforcement budgets -- or both.

(i) What is to be assigned?

There are three types of choices which must be allocated to particular levels of government in the assignment problem. These may be categorized as:

(a) the choice of objectives;

(b) the choice of control instrument; and

(c) the choice of implementation strategy.

(a) In an operational sense, the choice of the objectives of environmental policy will be manifest in the choice of desired ambient environmental quality and associated emission reduction targets. The choice of objective is based on the costs and benefits of emission control weighted

appropriately.[2] The assignment problem is then one of allocating the responsibility for decisions about these objectives.

(b) Once objectives have been set, a suitable control instrument must be chosen. There are two components of such a choice: first the qualitative nature of the control device - should emission quotas, pollution taxes, tradable permits, or some combination be used to modify the actions of polluters?; and second, the strength of the control instrument employed - how high should fines or taxes be.

(c) Finally, having decided upon an instrument of control and a target, the responsibility for implementing the policy must be allocated to a certain government body. These responsibilities will include inspections of firms, monitoring of ambient quality, enforcement of laws and collection of taxes. The efficiency with which these functions are performed by different levels of government help determine the appropriate assignment.

(ii) Formulating the assignment choice

Different assignments of the responsibilities in (a)-(c) above will contribute differently to overall potential and realized costs and benefits of environmental policy. The assignment problem is then one of choosing the allocation of responsibilities which yields the largest net increase in social benefits.

(a) To ensure maximal potential net increases in social benefits the agency which makes decisions about environmental objectives must be aware of all the possible benefits and costs of reduced emissions. This knowledge has two aspects: the qualitative nature of benefits and costs, and their quantitative significance.

---

[2]The weights are derived from the social welfare function used by the decision maker. For instance, if a local government chooses emission reduction targets which have external effects on other jurisdictions, these benefits may receive low welfare weights.

It might be expected that higher level government bodies are in a better position to include all types of direct and indirect benefits and costs (e.g. impacts on health, biodiversity, tourism, employment, technology, etc.) in their analysis, but that lower level agencies have a better understanding of the quantitative significance of any given factor, due to better on-the-ground information. However, this assertion is unlikely to be universally correct: due to communication barriers central governments may fail to include the effects of a national policy on some local communities;[3] on the other hand, officials on village councils are unlikely to have access to data about the long-term impact of global warming. Clearly, the nature of the pollution problem affects the assignment of responsibility for setting objectives.

Another important factor is the political economy of the decision making process. It may be that a particular government body is in the best position to calculate the total net social benefits associated with improvements in ambient quality. However, if the political process is open to lobbying by influential minority groups and/or corruption, then the resulting environmental policy may be too weak (if polluters lobby effectively) or too severe (if zealous environmentalists do so). A less than perfectly informed, but representative, government may be preferable to a fully informed, corruptible one.

(b) In deciding upon the type and strength of a control instrument, a government agency must consider the economic efficiency of the instrument and revenue effects. Weitzman (1974) has considered the efficiency properties of quantity based instruments (i.e. command and control policies, or CACs) and price mechanisms (market based instruments, or MBIs) under conditions of uncertainty

---

[3]Alternatively, the central government may be aware of the effects, but put zero weight on them. The existing distribution of income and political power are important in this respect, for instance in Nepal, where "little has been done to solve the [environmental] problems of the poor, because they represent the weaker sections of society and lack the ability to attract political attention and financial resources." (Asia Development Bank (1990)).

about costs and/or benefits of pollution control. Under certain conditions pertaining to the relative curvatures of the cost and benefit functions, a quantity standard is more efficient than a tax.[4] The government body which has more accurate knowledge of these functions should then be responsible for choosing the control instrument.

On the other hand, many developing country governments are revenue constrained, so any generation of public funds as a by-product of pollution control is welcome. Since most revenue sources are distortionary, the use of a corrective tax not only increases public funds, but can reduce dead-weight loss in the economy as well. This has implications for part (b) of the assignment problem: for example, if the tax base of local government is highly elastic and that of the central government is inelastic, the local government should be given access to the new source of revenue, since by reducing other local taxes it can remove more distortionary loss than can the central government. The relative efficiency of local versus central tax collection will be determined by, *inter alia*, the geographical mobility of the tax base, administrative capacities, and cultural norms. These are clearly empirical matters, and can be expected to vary between countries.

If a lower level of government is assured of sufficiently large grants from higher levels, it may opt for a low emission tax or light fines which are incapable of attaining the desired environmental improvement. On the other hand, if local governments are fiscally constrained with little help from the center, tax rates might be set above their optimal level. Thus the existing structure of inter-governmental financial relations is an important factor in the assignment problem.

(c) The implementation of pollution control policies may require the involvement of a number of levels of government. When polluters are hard to detect, a local monitoring agency may be more efficient than a national body. Estache (1991) reports that in Brazil, due to the small number of inspectors, it can be weeks before the state enforcement agency sanctions illegal logging activities.

---

[4]See Eskeland and Jimenez (1991) for an explanation of this result.

Local municipal enforcement may have been achieved in a much shorter time, with avoidance of adherent costs. On the other hand, inspections by a local agency may become predictable, while those of a central body, may be less predictable, and hence more effective. The relative degree of corruptibility of local and central government officials will clearly be important in this respect.[5] Analogous problems have been recognized in the case of Malaysian urban water supply by the Asia Development Bank (1990), which recommends,

> "[m]easures to improve the efficiency of governmental institutions and organizational structures in order to bring about a more concerted response to wastewater pollution problems..."

A further institutional constraint on enforcement is credibility. While local agencies may be most capable of identifying offenders, eliciting taxes or fines may be a protracted process. For example, the Korean Ministry of Environment is handicapped in the enforcement of laws regarding pollution discharges, due to lack of judicial power, which hinders access to plants suspected of violations.[6] If the government cannot commit to full enforcement, it may have to establish a reputation by undertaking long and costly legal battles. Local governments especially may not be in a position to engage in such long term strategic behavior (incurring high costs now so as to lessen future enforcement costs).

(iii) Intergovernmental incentives

Within a diversified control structure, there is a need to coordinate the actions of all relevant parties. This has been explicitly recognized in the case of water pollution in Malaysia, for example, where

---

[5]Ralston, Anderson and Colson (1983) present some evidence on the accountability of local officials.

[6]Asia Development Bank (1990).

> "..it seems certain that the problem can be solved only by joint participation of the federal, state, and local authorities. ...Thus to deal effectively with a widely recognized environmental problem will require institutional changes and new governmental relations."[7]

Government coordination is necessary for two reasons: each agency needs to know what it is supposed to do, and it must have an incentive to do it. The first requires sufficiently clear communication channels between government bodies. The second is problematic if the objectives of different agencies differ and, because of information problems, comprehensive inter-governmental contracts cannot be written.

Divergent objectives can be interpreted as deriving from the objectives of elected officials acting in the interests of their constituents.[8] When jurisdictions are distinct (e.g. two local authorities) or intersect (e.g. local and national bodies), the relevant constituents differ. If the objectives of each government body are determined by those of the median voter, for example, then they will in general diverge.

These divergences may be conveniently classified as vertical and horizontal, impeding the coordination of agencies in different tiers of government, and within the same tier, respectively. Vertical divergences create policy coordination problems when;

(i) local emissions affect state or national ambient quality. This fact may explain the observed superiority of the Dutch system of water pollution control (under the "Act on Pollution of Surface Water") over that of France. In France, regional bodies set and collect charges on polluting firms which are then distributed to local authorities to finance clean-up activities. However, according to Jansen (1991);

---

[7] *ibid.*

[8] Of course, the assumption of such benevolence is questionable. Not all governments are elected, and in any case, internal and external political pressures can lead to policies not in the true public interest.

> ..."it seems that the financial incentive to the French mayors is too low to elicit strong enough reaction."

In the Netherlands, the responsibility for clean-up rests with the regional authorities.

(ii) locally polluting firms are owned by non-local residents;

(iii) the central government is more responsive to international concerns. The case of Brazil is an obvious example. Alternatively, the international pressure may be indirect, as in Eastern Europe and the Mediterranean, where;

> "...most countries in the region aspire to one or another form of association the [European] Community, and hence wish to demonstrate their status as good Europeans by adopting environmental policies consistent with those of the Community.";[9] or

(iv) other budgetary responsibilities are ignored. For instance when health care is funded locally, if pollution control policies are formulated nationally, they must account for the full impact of ill health on the local budget.

Divergent objectives within a single tier of government will mean that some form of coordination is necessary to alleviate external effects such as

(i) transboundary pollution. Horizontal coordination may be preferable to central control, as has been recognized in Indonesia, where

> "[i]n order to make maximum use of existing personnel and other resources and to avoid establishing new agencies of uncertain capability, it would seem advisable to consider seriously the establishment of a pollution control or water management board, which would bring together the talents of all existing agencies.... Such coordinating bodies have proved to be more effective in other countries than the creation of independent new agencies.";[10] and

---

[9]Weiss (1991).

[10]Asia Development Bank (1990).

(ii) non-environmental external effects, such as cost exporting and tax competition between states.[11]

At higher levels of government, horizontal policy coordination is likely to be required when different ministries and departments have inconsistent mandates. For example, an Environment Department may insist on high prices to help attain reductions in electricity use and hence reductions in emissions from generating plants. However, a Consumer Affairs Department may wish to enforce low prices to alleviate monopoly distortions. The optimal policy would appear to be one of high prices and a tax on profits, but if this is infeasible, the two departments must coordinate their actions accordingly.

The implied coordination problems identified above may necessitate a change in inter-governmental relations and/or a modification of the assignment of responsibilities. This process is shown schematically in Figure 1 below. In the following two sections we examine specific examples of such changes and modifications.

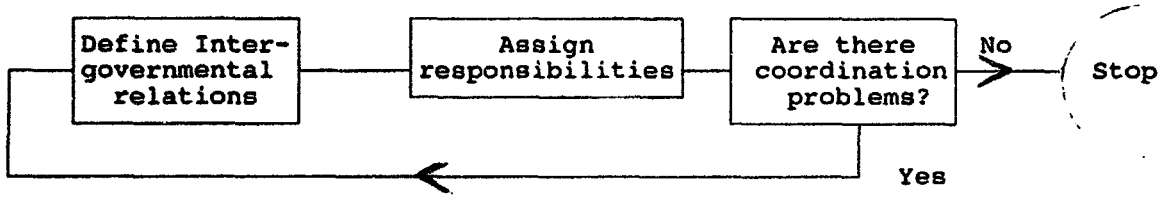

Figure 1

[11]Whether local governments set emission taxes and standards at inappropriate levels to attract investment and increase employment is debatable. For relevant contributions to this debate, see Estache and Taylor (1991b), and Oates and Schwabb (1988).

3. VERTICAL COORDINATION

In this section some stylized versions of vertical control structures will be considered. We concentrate on the delegation of monitoring and enforcement responsibility to local governments, with policy set by the center. Three general conclusions are drawn from the analysis:

(i) the need to induce local monitoring and enforcement activities may have implications for the choice of optimal control instrument (e.g. price or quantity instrument);

(ii) for a given instrument choice, the retention of some control over the local government's enforcement budget can effectively induce more efficient local monitoring policies; and

(iii) monitoring and enforce can be controlled more efficiently if additional (related) variables help determine inter-governmental transfers.

(i) Incentive schemes

When a pollution control policy is designed and implemented through a vertical regulatory structure, the incentives of each level of the hierarchy must be taken into account. An important vertical division of responsibilities is that between policy choice on the one hand, and monitoring and enforcement on the other.

In addition, local governments are usually permitted to raise their environmental standards above those mandated by the center[12]. However, we will concentrate mostly on the monitoring and enforcement issue, relying on the observation that in developing countries, national regulations are usually binding (in the sense that local pollution control policies rarely require more abatement than the national law, if one exists[13]).

---

[12]...although this is not always in the national interest. See Estache and Taylor (1991b), and also Hoel (1991) for an example in an international context.

[13]Estache and Taylor (1991a).

Note that we are not confining ourselves to the monitoring and enforcement of an ambient or emission standard only. Environmental taxes have to be collected if they are to have any behavioral effect. Similarly, if tradable permits are used, emission levels must comply with permit holdings.

We shall treat the inter-governmental problem within the principal-agent paradigm (see Box 1). In general, theoretical solutions to principal-agent problems exhibit complex properties, with optimal payments schedules often non-linear and sensitive to parameters. On the other hand, practical transfer or financing mechanisms should be transparent. For example, one of the reasons cited for the success of the Dutch environmental funding policies (GEPA and APSW) has been their ease of administration and the transparency of their rationale and effects.[14]

The outcomes sought at the local level must be feasible, and are determined by the availability of local resources. The central government can expand the set of feasible outcomes by the use of grants, training programs, and political support. However, the incentive problem will persist, and without proper motivation for efficient use, the resources may be wasted.

Inter-governmental incentive schemes can vary widely in sophistication. The selection of schemes will be based on their effectiveness, the institutional capacity of both government agencies, the need for stable fiscal relations, and their political feasibility. The schemes we consider include:

(i) those without an explicit financial transfer, but granting the local government additional revenue sources (e.g., allowing the local government to retain any taxes or fines collected in the enforcement of federally set policies);

(ii) those with simple transfers in the style of matching grants (e.g. the enforcement budget financed by the central government, with a component based on the induced compliance rate); and

---

[14]The General Environmental Policy Act includes a wide-based tax on fuel consumption, and the Act on Pollution of Surface Water levies a charge on water-borne emissions to finance treatment. See Jansen (1991).

Box 1: *Inter-governmental Relations and the Principal-agent Paradigm*

An hierarchical government structure can be characterized as a relationship in which the feasible actions and welfare levels of the lower level (i.e. local government) are determined in part by the actions of the higher level (i.e. the central government). For example, by the use of non-matching inter-governmental grants, the center can expand the set of feasible actions available to the local government.

On the other hand, matching grants are often employed as stimulative instruments, to encourage a local contribution to national objectives (see, for example, Shah (1991)). Presumably, explicit encouragement is needed if and when the private incentives of the local government are not sufficient to guarantee unsolicited contributions. In the context of pollution control, inter-governmental transfers can be used to induce specific behavioral responses from local governments, such as lower emissions, stricter enforcement, and more efficient monitoring.

One approach to these hierarchical incentive problems is described under the principal-agent paradigm. (See Stiglitz (1988) for a lucid exposition.) Within this framework, the central government has the ability to write contracts with the local government, stipulating various required actions and (perhaps) subsequent financial transfers.

The strength of the terms of the contract typically vary with the constitutional division of powers between government levels. For instance, in a unitary state such as Zambia, the "contracts" between central and local bodies may restrict the choices of local authorities substantially. Alternatively, in a loosely federated system such as Brazil or Yugoslavia, the contract terms may be less restrictive for the lower level.

In extreme cases of local autonomy, as in Papua New Guinea and Belgium for instance, inter-governmental relations may be better described as a bargaining game. Such a game theoretic framework has been applied extensively to international environmental problems, where as yet, no central planner exists (for example, Hoel (1991)). The principal-agent framework is preferred in this study to avoid the complications of endogenous constitution formation and public choice theory. We make the realistic assumption that much policy reform must occur within a fixed governmental hierarchy.

(iii) those with more complex transfer components (e.g. based on the local government's ex ante prediction of pollution levels, and ex post outcomes, or on the performance of other local authorities in similar circumstances).

In developing countries, the choice of incentive scheme may be limited to the simpler alternatives. For example, in remote areas, inefficient communications and unreliable payments from the central government may mean that instruments without explicit financial transfers are most appropriate.

(ii) Local governments as residual claimants

Local enforcement agencies need to be given appropriate incentives to implement national pollution control policies. Turel et. al. (1991) remark in the case of Turkey,

> "Obviously if [the] majority of the taxes and fines are to be transferred to the central administration, the local administrations will not feel compelled to collect these revenues."

This is an often cited reason for the inactivity of local governments in general. The central government's taxing power always threatens to result in at least part of any locally collected revenue finding its way to the national treasury.

Suppose the central government can credibly relinquish its right to arbitrarily appropriate local revenue. A simple solution to the incentive problem then is for the center to choose tax rates or emission quota and fine levels, and allow the local enforcement agency to retain all (or a fixed proportion) of the revenue it collects. Thus, Turel et. al. suggest that

> "[f]ines and charges collected locally...and local taxes...are burdened upon [the] local population, and should be left to local administrations."

The allusion to burden bearing suggests some kind of fairness criterion in the allocation of tax or fine revenue. However, irrespective of the equity implications of the policy, the incentive for allocative efficiency may be improved by allowing the local authorities to retain the revenue collected. In fact, this form of incentive mechanism is similar to the framework employed in the regulation of utilities in some industrial countries. In the United Kingdom for example, an average electricity price (emission tax in the present context) is set by the center, and the supplier (local government) given the rights to all profits (revenue).[15]

---

[15]See, for example, Vickers and Yarrow (1988).

From a pure public finance point of view, it is unlikely that such earmarking of public revenue from the implementation of pollution control mechanisms will be optimal. However, in a related context McCleary (1990) notes that

> "...earmarking may contribute to improved collection performance, and perhaps even a better utilization of the monies since concerned users and officials are better monitors of performance than more distant authorities."

If local administrations are to be given the correct incentives by allowing them to keep the proceeds from their monitoring and enforcement activities, the question then arises over the appropriate instrument to be used. We will show (the details are relegated to Appendix 1) that when the local government has some knowledge of firms' abatement costs, and cares only about revenue, a quantity instrument or technical design standard may dominate the use of a tax. This result is motivated below.

If there is to be any incentive problem between central and local levels of government, the objectives of each must differ. We take the objective of the central government to be a given reduction in pollution at least cost. Whatever the costs of enforcement, this will require that marginal abatement costs are equalized across firms.

As an extreme example, we will assume that the local government does not care about pollution. Centrally mandated pollution taxes or fines then represent an instrument for revenue generation, through which the local government can increase its budget. For a given level of resources committed to monitoring, the enforcement policy will be conducted so as to maximize tax or fine revenue.

If the local authority has no information about abatement costs, then a uniform inspection policy - i.e. one where the probability of inspection is the same for all firms - is probably the best option. However, if the local government has information about firms' costs, then it can choose to inspect some more often than others.

Consider the case of a centrally set emission tax rate. If the enforcement agency has a good idea of which firms have high costs of abatement and which have low, then it will aim its inspections at the high cost ones. This is because high cost firms will prefer to pay the tax on a relatively large emission base than to abate, whereas low cost firms would prefer to abate and face a smaller tax bill. Thus, concentrating inspection activities on high cost firms yields the local authority higher revenue.

Clearly, the low cost firms - if they know they will not be inspected for tax liabilities - will not reduce their emissions to the level required by the tax, so it will pay the government to inspect them with some low probability. Nonetheless, the equilibrium strategy of the government will be one of allocating a high proportion of its enforcement budget to the inspection of high cost firms.

In equilibrium, marginal costs of abatement will not be equalized across firms, so the reduction in emissions will be achieved at an inefficiently high cost. In fact, the perverse outcome can result whereby firms with high costs of abatement reduce emissions more than those with low costs. Clearly this does not conform with the center's objectives.

The problem lies in the fact that the local government, as a revenue maximizer, acts as an (imperfectly) discriminating monopolist. On the other hand, as shown in Appendix 1, if an emission standard is used, inspections will be biased towards low cost firms, which, in equilibrium, are responsible for the majority of abatement. This may be more cost effective than the outcome under the tax, and is due to the high cost in terms of inspections of eliciting a given compliance rate from high cost firms.

An alternative strategy available to the central government could be to use an instrument which restricts the local agency's ability to discriminate between firms. For example, a mandatory design standard (with accompanying fine) may impose the same costs of compliance on all firms. In this case the local government will employ a uniform inspection policy.

In both of these cases, the improvement in the central government's control of the local enforcement agency is obtained at the cost of assigning an instrument which is otherwise less efficient than a tax. However, when enforcement is costly and government objectives diverge, total costs may be lower.

(iii) The enforcement budget as a control device

In part (ii) above we considered the use of a simple implicit transfer mechanism to stimulate local enforcement activities, and the consequences for instrument choice. We now consider how, for a given instrument, the implicit transfer might be used to improve the enforcement incentives of local governments.

Our discussion is based on the work of Jones and Scotchmer (1990), who consider the implementation of a regulatory design or performance standard. The transfer mechanism available to the central government is defined in terms of the local authority's enforcement budget. The budget can be affected by the use of direct lump-sum payments (i.e. categorical grants), which govern its overall size. In addition, the central government can use a transfer conditional upon the enforcement policy chosen by the local authority. In particular, a proportion of the collected fines is used to finance the enforcement budget.

In the model, the objectives of the central and local administrations differ with respect to the weight given firms' costs of compliance (e.g. costs of abatement, costs of adopting the required technology, etc.). In particular, the local government does not take these into account, and seeks to maximize the compliance rate.[16] This is despite the fact that it has some knowledge, in the form of a signal, of the compliance costs. The signal is costless for the local authority to observe, and allows it to identify which firms, *ceteris paribus*, are likely to comply.

---

[16]This could arise because the firms are owned by interests in other parts of the country.

If inspection rates are equal across firms, compliance rates will be higher for those with low costs. Therefore, eliciting a given rate of compliance requires a greater probability of inspection for high cost firms than for low cost firms.

For a given enforcement budget, the local government's optimal inspection policy then induces a certain distribution of compliance rates. In fact, in the specific model employed by Jones and Scotchmer, uniform compliance rates for all inspected firms are induced, irrespective of their costs of compliance.[17] This is not optimal from a national perspective; the center, desiring cost effectiveness, would prefer firms with low compliance costs to comply more than those with high compliance costs.

However, if the enforcement budget is constrained, then firms with very high cost signals are not inspected at all. This is because eliciting compliance from these firms requires a very high inspection rate, which is costly for the local government. Thus restricting the size of the enforcement budget can ensure that those firms with very high compliance costs do not comply, in line with the center's objectives.

Of those inspected, the central government would like the lower cost ones to comply more. This will be possible if, for a given compliance rate, the marginal cost to the local authority of eliciting compliance of high cost firms can be made higher than that for low cost firms. The enforcement agency will then be induced to switch some inspections from high to low cost firms.

---

[17]This result is specific to the model. It is implicitly assumed that locally there is a one to one relationship between marginal and absolute compliance rates, independent of the cost signal. The local government's optimum is characterized by equal marginal compliance rates, and hence, by assumption, equal absolute rates.

If the local government does not receive any fine revenue, the marginal costs of eliciting compliance for low and high cost firms are equal when compliance rates are equal.[18] However, if the local government can retain a proportion of the fines it collects, then, at equal compliance rates, the marginal cost of eliciting compliance of high cost firms is higher than that for low cost firms. This is because

> "...[fine]rebates are lost on more inframarginal inspections in a high-cost class than in a low-cost class, and this makes the agency's effective marginal costs of inspections higher in the high cost sector."[19]

Hence by *linking the budget of the enforcement agency more closely to its actions,* the central government can induce more efficient targeting. By reducing the lump-sum component of the transfer, and forcing the agency to be partially self financing through its fine collections, the central authority can make the inspection of low cost firms more attractive than otherwise.

(iv) Comparative incentive schemes and enforcement

The transfer mechanisms of the preceding examples have been simple enough to implement, and have not required significant communication resources. In many developing countries this is an important constraint. However, by using a richer incentive structure, tighter control of the regulatory activities of the local government can be achieved. In middle income developing countries the necessary administrative infrastructure may well exist to facilitate this objective.

The general problem is that of regulating a regulator. When the local regulator cannot be controlled directly, the center needs to indirectly monitor its activities. One general method is to use a comparison with another observable variable to infer information about the local authority's actions. Three possibilities are discussed below:

---

[18]This follows since the marginal compliance rate is just the inverse of the marginal cost of compliance.

[19]Jones and Scotchmer (1990), page 68.

(a) comparing the performances of a number of local regulators. This is the idea of regulatory (or yardstick) competition;[20]

(b) comparing the performance of the regulator in different time periods; and

(c) comparing the ex ante predictions of the regulator with observable ex post outcomes.[21]

(a) Inter-jurisdictional Regulatory Competition

When two regulators are given similar tasks in similar situations, the results of their actions can be meaningfully compared. In this case, the results of one can be used to infer information about the actions of the other.[22]

Consider the motivation of enforcement effort. When there is only one regulating agent, it can claim that the costs of monitoring and enforcement are high, due to inspection difficulties or high compliance costs of firms. The center may then be forced to fund the local enforcement budget based on the exaggerated claim.

Now suppose neighboring communities face similar pollution problems (with no spill-over effects) and that each is to be controlled by a local regulator. If firms' abatement costs, and the effective costs of monitoring and enforcement, are both correlated across localities, the level of abatement attained in one can be used to determine the degree of effort exerted in the other.

More specifically, the enforcement budget of an agency can be positively tied to the difference between the ambient air quality of its jurisdiction and that of the other. While a part of the budget should cover "reasonable" costs (i.e. ones which the center knows must be covered), the

---

[20]See Nalebuff and Stiglitz (1982), Schleifer (1985).

[21]See Demski and Sappington (1987).

[22]This kind of competition has been used in some defence procurement contracts in the US.

variable part gives the regulator the incentive to enforce emission reduction until the true marginal costs of doing so equal the marginal benefits. If pollution levels in one community continue to be worse than expected, a revision of the "reasonable" costs may be necessary.

Of course, the mechanism is open to abuse if the local regulators can collude, and agree to some sub-optimal level of enforcement. Also, inducing this kind of regulatory competition is only desirable if the underlying costs in each jurisdiction are closely correlated.

(b) Inter-temporal Comparisons

Instead of comparing results between jurisdictions, where costs of enforcement may differ considerably, it is possible to compare performance in a single locality over time. If costs are positively correlated from year to year, then next year's budget can be made sensitive to relative improvements in ambient environmental quality.

One potentially perverse effect of this kind of scheme is that resources are transferred to localities which have good abatement records. Once a significant improvement has been achieved, the incentive transfers should be reduced. If no improvement occurs, it is not necessarily a sign that "effort" is lacking on the part of local governments, but that extra resources are needed to improve ambient environmental quality.

This points to the need to balance incentive costs with the actual costs of abatement. Concentrating solely on the first factor, in this example, may induce a local government to engage in no enforcement activities. If its initial enforcement budget is too low to effect a significant reduction in pollution, it may choose a zero enforcement level, knowing that its budget would not be increased in the following year in any case.

(c) **Using Firm Behavior to Monitor Regulatory Activity**

The previous examples have investigated ways of inducing local enforcement of central policies. This has been motivated by the observation in Section 2 that, *ceteris paribus*, local monitoring may be expected to be more efficient than central. Local governments can also be expected to have access to information regarding the potential for abatement, as well as whether it actually occurs. This knowledge is useful in policy choice, and is valuable to a central policy maker.

Suppose the central government wishes to give tax incentives to firms to invest in abatement technology. The size of the appropriate tax break depends on the costs of adopting the technology.[23] For example, if the adoption will cause serious disruption to production processes and other input markets, the required incentive is necessarily high.

The local government may be in a better position to determine these costs of adoption, but will likely incur a cost of its own in doing so. The center must then give the local authority sufficient incentive to become informed about abatement possibilities, and to transmit that information to the center.

One way to make it attractive for the local agency to become informed is to base its incentive payment on a comparison of the agency's ex ante prediction of pollution control, and the actual ex post outcome. If it is informed about the costs of adoption, then it will have a better chance of predicting the outcome. The center is then able to implement a more accurate tax incentive for the firm, since it has better knowledge about its adoption costs.

An advantage of this scheme is that the actions of the local authority need not be monitored by the center.[24] The only measurement that has to be made is, in the case of airborne emissions for example, that of the ambient air quality.

---

[23]If the technology does not exist, the adoption costs also include R&D expenditures.

[24]In fact, often it may be expected that they are not observable.

(v) Summary

We have seen that the incentive costs of a particular assignment choice may be reduced by the use of implicit or explicit inter-governmental transfer schemes. These schemes vary in sophistication, requiring various institutional capacities, and resulting in outcomes of varying efficiency.

4. HORIZONTAL CO-ORDINATION

In the previous section we analyzed various vertical inter-governmental structures as they related to pollution control mechanisms. But in practice, each of the levels of government is divided horizontally, at the local level along jurisdictional lines, and at the central level into ministries and departments. It was shown in Section 2 that objectives may well diverge between agencies within the same level of government. In this section we discuss ways of coordinating the actions of these horizontally related bodies.

The obvious mechanism by which horizontal coordination failures can be resolved is that of recentralizing the decision process. The costs of such a proposal may be high, and the extent to which inter-jurisdictional and inter-ministerial coordination failures are replaced by bureaucratic incompetence suggests that the resolution will be far from complete, and will most likely result in negative net consequences.[25]

The present section is divided into two parts. The first addresses some coordination problems at the local level arising from environmental spillovers. It will be seen that, contrary to the Coasean orthodoxy, the assignment of property rights can matter, and the appropriate initial distribution of these can be an effective policy instrument. Operationally, this translates into an *efficiency* (as opposed to equity) argument in favor of uniform ..ational standards. The second part

---

[25]Estache and Taylor (1991b) note a similar point.

considers the problems of inter-ministerial coordination at the central level, and suggests that explicit methods of policy management be pursued, such as the use of high-level inter-departmental committees.

(i) Environmental spillovers, negotiations, and property rights

If pollution crosses jurisdictional boundaries, should the central government apply uniform emission standards to all local bodies, or should the individual local governments be able to choose their environmental policies themselves? This is an example of the first dimension of the assignment choice identified in section 2 - viz. who should decide on ambient quality targets or emission levels? As long as all affected parties can negotiate efficiently, and there are no extreme disparities of income between jurisdictions, there should be no reason for the central government to be involved. This sub-section examines some of the impediments to efficient negotiation, and policy prescriptions for their alleviation.[26]

We will see that in some important cases, a passive agency encompassing the full extent of the pollution problem can effectively facilitate the coordination of its members. The agency is not required to actively participate in the negotiation mechanism, but fills the role of an information processor. In general, it can ensure coordination by allocating pre-negotiation property rights appropriately. This allocation can be achieved operationally by applying a uniform standard across jurisdictions with the proviso that the standard may be exceeded as long as all affected parties agree.

---

[26]When there are no spillover effects there will be no need for jurisdictions to negotiate on environmental matters. Oates (1990) has argued strongly that uniform standards in the US are very costly for California and that targets should be set on a state by state basis. Uniformity, in this case, may be a result of what he describes as "political realities".

Alternatively, negotiations can be expedited through the use of a subsidy. It should be noted however, that this is not a subsidy to abatement in the usual sense, and is thus not open to the criticisms of such instruments.[27]

We consider a simple case of one jurisdiction emitting pollutants which hurt another. This is the most oft-cited form of externality in the economics literature. The alternative to active central intervention (by means of direct regulation, or a Pigouvian tax - i.e. a matching grant) is a negotiated settlement between the parties. It is assumed that local governments control the pollution of resident firms, and that it is the local governments which negotiate. There are at least two impediments to this Coasean method of resolution.

First, the local governments may not have the institutional capacity to enable efficient communication. In poor areas, isolated by long distances, but nonetheless environmentally interdependent, this can be a significant problem. Unregulated motorized pumping for irrigation in Bangladesh is a major factor in the lowering of the water table which renders shallow wells with suction pumps in other jurisdictions ineffective.[28] In such cases it may be necessary for the central or regional government to provide the requisite infrastructure, or to make second best decisions itself.

A more fundamental constraint to efficient Coasean negotiation is the presence of private information. To see this, consider Figure 2. Town 1 emits pollutants at a rate y into a river which is used by town 2. The marginal benefit to town 1 decreases as emissions increase, while the marginal damage to town 2 increases with emissions. Town 1 would like to emit at a level of y', while its optimal level of emissions is y^*. We may think of y' as the total potential level of emissions, the rights to which are divided between the towns. At the optimum, town 1 receives y^* emission rights,

---

[27]In particular, it has been argued that abatement subsidies may discourage technical innovation, or lead to excessive entry into a polluting industry.

[28]Briscoe and deFerranti (1988).

and town 2 (y'- y*) , which it does not use. The Coasean theory of bargaining says that in a situation like this, the initial allocation of pollution rights does not effect the final allocation if it is possible for the parties to trade efficiently. Thus, if initially town 1 has y' rights, it will sell (y'-y*) to town 2 at such a price that both towns will be better off. Similarly, efficient emission levels result after trade if town 2 has y' rights initially (this is often described as town 2 having the right to pollutant-free water).

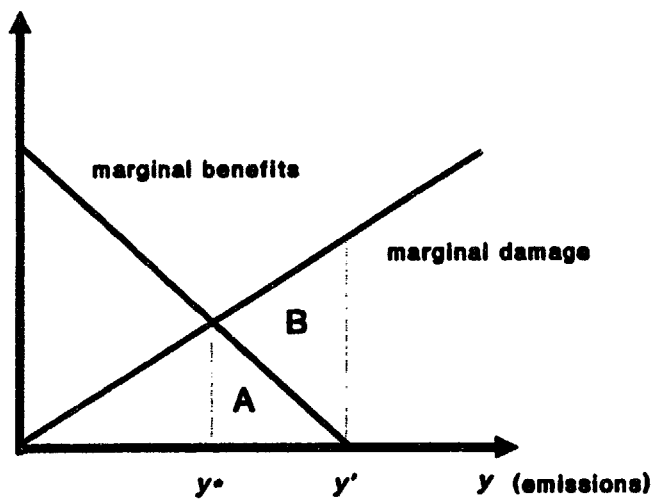

FIGURE 2

However, if the benefits and costs of emissions are privately known, then in any negotiation each party will have an incentive to misrepresent the impact of emission control on itself. Town 1 will claim that the costs of abatement are prohibitive, while town 2 will claim that increased emissions impose on it a high social cost. It is hard for each to know what y* is in this case.

Nonetheless, it is possible for the parties to devise contracts which make it in their individual interests to tell the truth about the effects of pollution. This is the general problem of mechanism design (see Myerson, 1979, 1981). Truthful revelation is achieved by requiring that side

payments be made which explicitly incorporate the negative effects that each claim has on the other party. Defining the side payments in this way ensures that each agent internalizes any external effects of its reported preferences. Thus, if the polluting town 1 claims high costs of abatement, then it receives a large allocation of pollution rights. However, this imposes high external costs on the polluted party, town 2, and so town 1 is required to pay for its claim. As Farrell (1987) notes,

> "This is not for reasons of justice or equity (though those might apply too); it is because only if you [the polluter] must make such a payment will you have the right incentives to claim intense preference when, and only when, you feel it."

This principle can be seen as a general rule for allocative efficiency: you should pay for (receive in accordance with) the effects of your (others') actions.[29]

Suppose, for example, that town 1 initially holds the right to pollute. From Figure 2, it can be seen that for the given marginal damage curve of town 2, town 1 must receive a payment equal to the area A + B to induce it to truthfully reveal its marginal benefit schedule. On the other hand, for a given marginal benefit curve for town 1, town 2 will reveal its marginal damage schedule truthfully only if it must pay a sum equal to area A . This payment system is incentive compatible, and results in the efficient level of pollution, y^* .

There is an immediate problem however with this mechanism. The required payment *by* town 1 is less than the required payment *to* town 2, the difference being the area B . It is thus unworkable, unless a lump-sum subsidy of at least that amount is available. One source for such a subsidy is from outside the system - e.g. from the general revenue of the central government.[30] Alternatively, the towns may be willing to pay a lump-sum fee into a fund to cover the financing requirements, equal to the expected value of B , before they enter negotiations. But suppose town

---

[29]Bird (1990) has espoused this principal in the context of inter-governmental financial transfers.

[30]This possibility is discussed below.

2 suffers very little damage at the margin: it has little to gain from a slight reduction in the emissions of town 1, so will not be willing to contribute much to the fund. Similarly, if town 1 has very high marginal benefits from pollution, it will not stand to gain much from the mechanism. In this case, the towns will not be willing to pay E(B) beforehand to join the negotiation.

The same problem arises if town 2 initially has the rights to y' units of emissions. However, when the rights to emissions are initially distributed evenly between the towns, it turns out each town is willing to pay enough to join the negotiating mechanism. The reason is that now, each town, no matter what its marginal benefit or damage schedule, expects to make a sizable gain from trade. Now if town 2 has a low damage schedule it will expect to trade most of its rights to town 1 and make a profit: if town 1 has high costs of abatement, it will expect to increase its emissions and also make a profit. Even the towns with middling or average benefit or damage schedules will expect to make sufficient profits to be willing to contribute to the financing requirement. This result stems from the work by Myerson and Satterthwaite (1983), and Crampton et.al. (1987) An illustrative numerical example is presented in Appendix 2.

The reason why the redistribution of initial emission rights alleviates the inefficiency problem can be stated as follows. To ensure truthful revelation, and hence efficient emission levels, the incentive compatible payment system described above must be used. However, the mechanism results in a deficit, which must be financed by lump-sum contributions if the incentives of the towns are not to be distorted (and truth-telling lost). When pollution rights are initially skewed in favor of one town, there are some types of town that will gain very little from engaging in the mechanism, and they will be unwilling, *ex ante*, to make lump-sum contributions to cover the expected deficit. When pollution rights are more evenly distributed, all types of each town expect to gain significantly from the mechanism, and are thus willing to finance it.

Operationally, the result suggests that initially uniform standards across jurisdictions may be used to aid negotiations when information about costs and benefits is privately held. These standards may then be breached with the consent of all affected parties. It is stressed that the institutional capacity must exist for such negotiations to take place, but that this alone may not be sufficient.

Alternatively, the central government may expedite the negotiation process by making non-negotiation look relatively unattractive. Thus, heavy sanctions could be levied upon disagreeing local governments. However, this is open to strategic abuse, say if a weak local body was held to ransom by a stronger neighbor. The relative attraction of participating in negotiations could be achieved by the central government giving the local participants a reward if they reach a settlement. This can be thought of as a subsidy to negotiation, as distinct from traditional subsidies to abatement.

The solutions of the previous paragraph require the intervention of the regional agency in a non-decision-making role. That is, the regional authority does not change marginal incentives (e.g. marginal costs of abatement by the use of an emission tax or abatement subsidy), so does not need to know the characteristics of the negotiating parties in detail. In this sense its role is passive, and may not be too difficult to implement.

On the other hand, problems may arise. If a subsidy scheme is proposed, then it can be implemented by allowing the side payments to be made through the center. This places the center in somewhat of a monopolistic/monopsonistic position. If it acts in a profit maximizing fashion, then its optimal strategy is to restrict trade, and the result will be socially sub-optimal.[31] Since the central and regional governments in developing countries often face tight budget constraints, the temptation to act in this way could be considerable.

---

[31]See Myerson and Satterthwaite (1983), Theorem 4.

Thus, to overcome the information-induced barrier to the efficient allocation of emissions, the central authority has three alternatives:

(i) It can act as a broker or financial agent between the localities, and implicitly contribute a subsidy to the negotiating process. This arrangement will be susceptible to the following disadvantages:

(a) The center could act as a profit maximizer, and exploit its monopolistic/monopsonistic position.[32]

(b) The municipalities could collude, and elicit a larger subsidy than required from the center. This possibility may not be significant, since the ability to collude would suggest an efficient bargain was possible in the first place.

(c) The additional transactions costs may be important, and could lead to implementation delays.

(ii) It can threaten sanctions against the localities (e.g. the withholding of future intergovernmental grants) to force the agents to participate in the contract. The main constraints impeding this approach are:

(a) The credibility of the regional authority's threat (i.e. the problem of time inconsistency[33]).

(b) The possibility of strategic delays by towns with strong bargaining positions.

(c) The legality and/or political feasibility of such a policy.

(iii) It can define property rights in such a way that the participation constraints do not bind. This may be achieved by setting uniform standards which can be breached only with the consent of all relevant parties.[34] The significant attraction of this approach is that it requires no outside subsidy. The primary concerns with the policy are:

---

[32]Bulow and Rogoff (1988, 1990) similarly note the possible inefficiency of involving a self-interested third party in debt negotiations.

[33]Kydland and Prescott (1977).

[34]The initial allocation, y'/2 each, need not be symmetric. In general the participation constraints will be non-binding for a range of initial allocations centered on the equal shares point. See Crampton *et. al.* (1987).

(a) Possible rent-seeking behavior of municipalities - it may not be easy to change traditional property rights;

(b) The commitment of the center not to interfere with the *ex post* outcome of the bargaining process; and

(c) The possibility that a polluting locality will strategically increase its emissions above its desired level before the central authority allocates the shares (so that ex post it gets a larger, and possibly most preferred, absolute level of pollution rights).

The rent-seeking problem can be circumvented by committing, through legislation, to an equal shares rule (i.e. setting the uniform standard at half the unnegotiated pollution level, y'). The general problem of commitment in (b) is a characteristic of all government policies, and there is no reason why it should be any more problematic in the present circumstance. Finally, the possible negative effects of strategic behavior could be mitigated by the use of a range of past emission levels in the allocation of property rights (say by letting y' be some weighted average of past emission levels).

Do these arguments have any empirical basis? It is always difficult to distill single causes or effects from complex bargaining processes, but the following example is illustrative of the notion that outside coercion may be necessary to bring parties to the negotiating table. In the late 1960s it became apparent to some Dutch farmers that their source of water, the greater Rhine river system, was being contaminated by French salt mines upstream. Potential gains from trade went unrealized as the French, who possessed full de facto rights to the use of the water, refused to negotiate. In the early 1980s, the European Court handed down a judgement compelling France to negotiate This resulted in the French finding an alternative means of disposal for unused salt, paid for by the Netherlands.

Distributional Issues: A Caveat

The models of Myerson and Satterthwaite (1983), and Crampton *et. al.* (1987) discussed above implicitly assume a constant marginal social utility of income, common to all localities or towns. Also, the incomes of each are assumed to be high enough to cover any necessary side payments. These two assumptions, especially the first, may not hold in inter-jurisdictional matters.

Bird (1990) has suggested that inter-governmental grants can only be defended as equalization instruments if they can improve allocative efficiency. Whether this is acceptable or not is debatable, but the present case shows that efficiency improvements can be achieved, in theory, by improving the distribution of income.[35]

The general issue is whether environmental policy should be used as a redistributive instrument, or if the equity consequences should be managed by the central government through explicit distributional policies. This will clearly depend on the efficacy of redistributive programs. If these are weak or non-existent, weight may also have to be given to the distribution of income in the design of pollution control policies.

For example, suppose a low income town is adversely affected by the discharges of an upstream factory. Even if property rights are distributed as described above (i.e. "evenly"), the downstream town may not be able to afford to pay for a further reduction in emissions. If redistributive programs are ineffective, it may be better for the central government to directly intervene and force a further reduction. The efficient discharge level may not result, but without increasing the poor town's income explicitly, this central intervention may at least improve the outcome.

---

[35]That is, if incomes are unequally distributed, the use of welfare measures which are additively separable in money and the disutility of emissions may not be meaningful.

(ii) Inter-ministerial coordination

Nearly all governments have some kind of ministerial division of responsibilities and powers. As soon as the policies of one portfolio have consequences for those of another, there is a strong possibility that uncoordinated actions will yield inefficient outcomes.

Often these problems are dismissed as "political", deriving from rent-seeking behavior on the part of high ranking officials. This is certainly a problem in many countries - developing and industrial alike - but coordination problems can arise from the specific mandates of the ministries involved, even when officials act in accordance with these mandates.

As before, the divergence in ministerial objectives can be interpreted as deriving from mandates which refer to the welfare of different groups of individuals. This suggests that when efficient ministerial actions are not forthcoming, some institutional change is necessary. These may be in the form of improvements in the consistency of mandates, or the creation of explicit coordinating institutions (e.g. high-level inter-departmental committees).

There are many examples of inter-ministerial coordination problems. For example, the Environment Ministry in Turkey has the responsibility of protecting natural resources. In potential tourist areas this would require some control over development projects. However, housing and lodging are the official responsibility of the Ministry of Construction and Settlement.[36] These ministries implicitly act in the interests of different groups: the first predominantly in the interests of local residents, and the second in the interests of holiday makers (and developers).

An example of acid rain caused by sulfur emissions from power plants in the mid-west of the US has been studied by Baron (1985). Here the Environmental Protection Agency (EPA) and the public utility commission (PUC) are involved. The EPA is charged with protecting environmental

---

[36]See Turel *et. al.* (1991). Other examples not explicitly related to pollution questions are described in Bahl *et. al.* (1984).

quality throughout the US, while the PUC's mandate essentially requires fair treatment for consumers. However, in the case of acid rain, the individuals affected by the pollution (residents of New England) differ from the consumers of electricity in the mid-west. A cost effective reduction in emissions would generally require both a reduction in output (with consequent increase in price) and a modification of the production process (e.g. through the installation of scrubbers). However, the PUC is unlikely to be willing to raise the price to the efficient level, since this would mean mid-westerners were paying for the benefits of lower emissions accruing to New England residents.[37] The EPA, taking this into account, will be forced to require the adoption of a more stringent technical standard than otherwise.

This kind of uncoordinated behavior would not be inefficient if the ministries' mandates were consistent (i.e. referred to the same individuals).[38] The example shows however, that in the case of pollution control, inconsistent mandates can prevent cost effective emission reductions. Another example from the US is the ongoing dispute between the Los Angeles Department of Water and Power (supplying water and electricity to 3.4 million customers) and the California Department of Fish and Game over the use of water from the Owens River.[39]

One solution to these horizontal coordination problems is to precisely and exhaustively define consistent mandates. This, however, would require the identification of a large number of contingencies. It would most likely shackle the central government with red tape, the costs of which would outweigh the efficiency gains sought in the original ministerial division.

A more plausible alternative would be to create a formal or informal institution to facilitate inter-departmental coordination. Thus, the efficiency gains of the ministerial structure could

---

[37]This assumes that property rights initially reside with the generators of electricity.

[38]Note that if two agents' objectives are identical, Nash equilibrium is efficient.

[39]New York Times, (1991).

be retained, while averting unnecessary conflicts of interest. Importantly, the representatives on the coordinating body must have sufficient authority to negotiate on behalf of their departments, and if necessary make compromises. Otherwise, as witnessed in some industrial countries (e.g. Australia), inter-departmental committees can prove ineffective in engaging in meaningful dialogues over shared concerns. Finally, it is noted that in practice, inter-ministerial and vertical coordination problems may easily be juxtaposed. For example, in Quang Ninh province in north-eastern Vietnam, heavily polluting coal mining is undertaken by a national state owned enterprise. However, health care responsibilities rests with the local governments. It is clear from the direct linkage between these activities that both inter-sectoral and inter-governmental coordination is likely to be necessary.[40]

(iii) Summary

Inter-jurisdictional pollution problems can be addressed through active or passive involvement of the central government. Active intervention policies include jurisdiction-specific emission standards, abatement subsidies (i.e. matching grants), and Pigouvian taxes. These require information about relative costs and benefits of emissions to the relevant localities. Passive instruments can be used to facilitate efficient Coasean bargaining between the jurisdictions, avoiding the information requirements characteristic of active instruments, but are effective only if good communication channels exist between localities.

At the level of central government, inter-ministerial coordination failures are often the consequence of inconsistent mandates. One solution is to precisely define ministerial mandates so that no inconsistency arises, but this is likely to be infeasible. High-level inter-departmental committees may then be required to explicitly coordinate central government policy.

---

[40]See United Nations Development Program (1991).

5. CONCLUSIONS AND POLICY IMPLICATIONS

A number of characteristics of pollution control programs have been identified which suggest that it is unlikely that any single level of government should undertake all aspects of an environmental policy. Policy decisions regarding targets and instruments should be made with respect to the most accurate and complete information available, and should encompass the full extent of the problem. Effective implementation, including inspection, enforcement, and prosecution may require the involvement of all levels of government.

However, for any assignment of responsibilities between and within levels of government, an additional cost may be significant. This is the cost of coordinating government actions, and arises from the divergence of objectives of different governmental bodies. Uncoordinated actions can then result in inefficient outcomes.

The coordination of government policies can be improved by the use of inter-governmental incentive schemes. These may be more or less sophisticated, depending on the institutional capacity of the public sector. All seek to maintain a degree of local decision making authority, but to modify the incentives faced by local administrators. They can be used to facilitate coordination between different levels of government (vertical coordination), or between administrative bodies within the same government tier (horizontal coordination).

There is a range of instruments available for vertical policy coordination. Their use depends on the sophistication of inter-governmental transfer mechanisms, the responsibilities delegated to lower level agencies, the objectives of each level, and the information structure between these levels. We have dealt particularly with the problem of inducing local authorities to adopt efficient monitoring and enforcement policies.

One incentive device is to grant the local government financial autonomy, in the sense that any taxes or fines it collects as a result of enforcement are retained locally. While this increases

the level of enforcement, if the local government maximizes revenue, it may introduce some bias in the qualitative nature of inspection policies. For example, if an emission tax is used, firms with high costs of abatement could be forced to bear most of the reduction in emissions. On the other hand, when the local government enforces a standard, most abatement is carried out by low cost abaters, which is more efficient. Therefore, there are substantive implications for the choice of control instrument (tax or standard).

A more subtle form of financial incentive is that of explicitly affecting the enforcement budget of a local regulator. It has been seen that by controlling the size of the budget directly through lump-sum transfers, and indirectly through fine rebates, the central government can modify the inspection activities of a local regulatory agency in a welfare improving fashion.

Finally, when the central government can make informative comparisons, it may be able to improve the incentives of local agents. This comparison may be with respect either to the outcomes of actions by other local authorities, to the outcomes of previous actions by the same local authority, or to the behavior of the firms under the local regulator's control. The general point is that the central government should make use of as much information as is practicable to help reduce principal-agent costs.

When local decisions are sub-optimal from a regional or national perspective due to inter-jurisdictional environmental spillovers, a number of horizontal coordination instruments are available. These include regulatory matching grants and the direct imposition of specific emission quotas for each locality. However, the central government must have accurate information if this type of active involvement is to succeed.

Alternatively, local governments can negotiate mutually beneficial environmental policies. The central government then has open to it three forms of passive coordination policies to aid such negotiations. It can provide incentives for the local governments to negotiate by rewarding them if

they sign an agreement or punishing them if they don't. In each case it will be better for the parties to come to the negotiating table rather than stay away. The third policy is to set moderate but binding uniform national (or regional) emission standards which can be breached only with the consent of all affected parties. This has the effect of dividing the initial property rights equally between local authorities which ensures all will wish to participate in the negotiation process we have described.

Non-environmental spillovers can result from specific policy choices. For example, tax competition and cost exporting may occur if there is sufficient mobility of goods and capital. If this leads to inefficient levels of pollution, central regulation may be necessary. However, this is more an argument for improved fiscal policy in general, than environmental policy coordination in particular.

Environmental policies will typically affect, or be affected by, other sectors of the economy. When these sectors are subject to some kind of government policies, the coordination of the actions of different ministries becomes important. Even when ministers act in accordance with their individual mandates, their actions may conflict if decided upon non-cooperatively. One solution to this problem is to precisely and exhaustively define the responsibilities of different ministries and departments. However, this will be virtually impossible in practice, so a more effective approach is to have an explicit coordinating body (for example, a high-level inter-departmental committee).

Given the range of potential inter-governmental incentive instruments discussed above, and the qualitative diversity of pollution problems in developing countries, future research should be directed at understanding which schemes are useful and practically implementable. This will require careful consideration of inter-governmental relations, and the plausibility of their modification.

BIBLIOGRAPHY

Akerof, George (1970): "The Market for Lemons", Quarterly Journal of Economics, 84(3), 488-500.

Asia Development Bank (1990): Economic Policies for Sustainable Development, ADB.

Atkinson, Anthony and Joseph Stiglitz (1980): Lectures on Public Economics, McGraw Hill, (UK).

Bahl, Roy, Jerry Miner and Larry Schroeder (1984): "Mobilizing Local Resources in Developing Countries", Public Administration and Development, 4, 215-230.

Baro, David and Roger Myerson (1982): "Regulating a Monopolist With Unknown Costs", Econometrica, 50, 911-930.

Baron, David (1985): "Noncooperative Regulation of a Nonlocalized Externality",Rand Journal of Economics, 16(4), 553-568.

Bartone, Carl (1990): "Water Quality and Urbanization in Latin America", Water International, 15, 3-14.

Baumol, William and Wallace Oates (1988): The Theory of Environmental Policy, Cambridge University Press.

Besanko, David (1987): "Performance Versus Design Standards in the Regulation of Poliution", Journal of Public Economics, 34, 19-44.

Bienen, Henry, Devesh Kapur, James Parks and Jeffrey Riedinger (1990): "Decentralization in Nepal", World Development, 18, 61-75.

Bird, Richard (1990): "Inter-governmental Finance and Local Taxation in Developing Countries: Some Basic Considerations for Reformers", Public Administration and Development, 10(3), 277-288.

Bolton, Patrick and Joseph Farrell (1990): "Decentralization, Duplication, and Delay", Journal of Political Economy, 98(4), 803-826.

Briscoe, John and David deFerranti (1988): Water for Rural Communities: Helping People Help Themselves, World Bank.

Bulow, Jeremy and Kenneth Rogoff (1988): "Multilateral Sovereign Debt Reschedulings", International Monetary Fund, Staff Papers, 35, 644-57.

Bulow, Jeremy and Kenneth Rogoff (1990): "Cleaning up Third World Debt Without Getting taken to the Cleaners", Journal of Economic Perspectives, 4(1), 31-42.

Campos, Jose Edgardo (1989): "Legislative Institutions, Lobbying, and the Endogenous Choice of Regulatory Instruments: A Political Economy Approach to Instrument Choice", Journal of Law, Economics, and Organization, 5(2), 333-353.

Chikulo, B.C. (1985): "Reorganisation for Local Administration in Zambia: An Analysis of the Local Administration Act, 1980", Public Administration and Development, 5, 73-81.

Coase, Ronald (1960): "The Problem of Social Costs", The Journal of Law and Economics, 3, 1-44.

Conyers, Diana (1984): "Decentralization and Development: a Review of the Literature", Public Administration and Development, 4, 187-97.

Crampton, Peter, Robert Gibbons, and Paul Klemperer (1987): Dissolving a Partnership Efficiently", Econometrica, 55(3), 615-632.

Demski, Joel and David Sappington (1987): "Hierarchical Regulatory Control", Rand Journal of Economics, 18(3), 369-383.

Downing, Paul and William Watson (1974): "The Economics of Enforcing Air Pollution Control", Journal of Environmental Economics and Management, 1, 219-236.

Eskeland, Gunnar and Emmanuel Jimenez (1991): "Choosing Policy Instruments for Pollution Control: A Review", World Bank working paper, WPS 624.

Estache, Antonio (1991): "Municipal Environmental Issues in Brazil", mimeo, World Bank.

Estache, Antonio and Leon Taylor (1991a): "Surface Water Pollution Control in Brazil: An Overview of the Policy Issues", mimeo, World Bank.

Estache, Antonio and Leon Taylor (1991b): " Controlling Water Pollution in Brazl: Which Government Level Should Do What?", mimeo, World Bank.

Fargeix, Andre (1990): "Environmental Fund as Instrument of Environmental Polic", World Bank working paper (draft).

Farrell, Joseph (1987): "Information and the Coase Theorem", Journal of Economic Perspectives, 1(2), 113-129.

Green, Jerry and Jean-Jaques Laffont (1979): Individual Incentives in Public Decision Making, North-Holland, Amsterdam.

Groves, T. and J. Ledyard (1977): "Optimal Allocation of Public Goods: A Solution to the "Free-rider" Problem", Econometrica, 45, 783-809.

Heady, Christopher (1990): "Public Sector Pricing in a Fiscal Context", World Bank Research Observer.

Helm, Dieter and Stephen Smith (1987): "Assessment: Decentralisation and the Economics of Local Government", Oxford Review of Economic Policy, 3(2), i-xxi.

Hoel, Michael (1991): "Global Environmental Problems: The Effects of Unilateral Actions Taken By One Country", Journal of Environmental Economics and Management, 20, 55-70.

Jack, William (1990): "Taxation and Pollution Control: A Theoretical Analysis", D.Phil. thesis, Oxford University.

Jansen, H.M. (1991): "Western European Experiences With Environmental Funds", Institute for Environmental Studies.

Jimenez, Emmanuel, Vicente Paqueo and Ma. Lourdes de Vera (1988): "Does Local Financing Make Primary Schools More Efficient? The Philippine Case", World Bank working paper, WPS 69.

Jones, Carol and Suzanne Scotchmer (1990): "The Social Cost of Uniform Regulatory Standards in a Hierarchical Government", Journal of Environmental Economics and Management, 19, 61-72.

Kennedy, David (1986): "Controlling Acid Rain, 1986", John F. Kennedy School Of Government, Harvard University.

Kydlnd, Finn and Edward Prescott (1977): "Rules Rather Than Discretion: The Inconsistency of Optimal Plans", Journal of Political Economy, 85(3), 473-491.

Maddock, Nicholas (1990): "On the Monitoring and Evaluation of Rural Development Projects Under Decentralization", TWPR, 12(3), 249-260.

McCleary, William and Evamaria Uribe Tobon (1990): "Earmarking Government Revenues in Colombia", World Bank working paper, WPS 425.

McCleary, William (1991): "Earmarking Government Revenues: Does it Work?", World Bank Research Observer, Volume 6, Number 1.

Mensah, Edward and Kevin Croke (1990): "Determinants of Decision Making Under a Decentralized Regulatory Environment: A Case Study of the Asbestos Hazards Emergency Response Act (AHERA)", Journal of Environmental Systems, 19(3), 231-236.

Myerson, Roger (1979): "Incentive Compatibility and the Bargaining Problem", Econometrica, 47, 61-73.

Myerson, Roger (1981): "Optimal Auction Design", Econometrica, 47, 61-73.

Myerson, Roger and Mark Satterthwaite (1983): "Efficient Mechanisms for Bilateral Trading", Journal of Economic Theory, 29, 265-281.

Nalebuff, Barry and Joseph Stiglitz (1983): "Prizes and Incentives: Towards a General Theory of Compensation and Competition", Bell Journal of Economics, 14(1), 21-43.

New York Times (1991): "Los Angeles Considers Giving Water to Gain It", New York Times, May 18, 1991.

Oates, Wallace, (1990): Public Finance with Several Levels of Government: Theories and Reflections", paper presented to the 46th Congress of the International Institute of Public Finance, Brussels.

Oates, Wallace and Robert Schwabb (1988): "Economic Competition Among Jurisdictions: Efficiency Enhancing or Distortion Inducing?", Journal of Public Economics, 35, 333-354.

Opschoor and Vos (1989): Economic Instruments for Environmental Protection, OECD, Paris.

Pigou, A.C. (1920): The Economics of Welfare, London.

Ralston, Lenore, James Anderson, and Elizabeth Colson (1983): Voluntary Efforts in Decentralized Management: Opportunities and Constraints in Rural Management, Institute of International Studies, (Berkeley).

Rondinelli, Dennis (1990): "Financing the Decentralization of Urban Services in Developing Countries: Administrative Requirements for Fiscal Improvements", Studies in Comparative International Development, Summer 25(2), 43-59.

Salmon, Pierre (1987): "Decentralisation as an Incentive Scheme", Oxford Review of Economic Policy, 3(2), 24-43.

Sandmo, Agnar (1975): "Optimal Taxation in the Presence of Externalities", Scandinavian Journal of Economics, 77, 86-98.

Schroeder, Larry (1988): "Intergovernmental Grants in Developing Countries", World Bank working paper, WPS 38.

Shah, Anwar (1990): "The New Fiscal Federalism in Brazil", World Bank working paper, WPS 557.

Shleifer, Andrew (1985): "A Theory of Yardstick Competition", Rand Journal of Economics, 16(3), 319-327.

Stiglitz, Joseph (1988): "Principal and Agent", Princeton University Discussion Paper, #12.

Takemoto, Kazuhiko (1989): "Air Pollution Mitigation Strategies: Lessons From Japanese Experience", Working paper, Environment Division, Technical Department, Asia Regional Office, World Bank.

Tiebout, C.M. (1956): "A Pure Theory of Local Expenditures", Journal of Political Economy, 64, 416-424.

Turel, Oktar et. al. (1991): "Environmental Policy Objectives and Earmarked Funds", Turkish Social Science Association.

United Nations Development Program (1991): Report on Vietnam, Human Development Programming Office.

Vickers, John and George Yarrow (1988): Privatisation: An Economic Analysis, MT Press, Cambridge, Mass.

Weiss, Charles (1991): "Patterns of Environmental Management", Environment Division, Technical Department, EMENA Region, World Bank (draft).

Xepapadeas, A.P. (1991): "Environmental Policy Under Imperfect Information", Journal of Environmental Economics and Management, 20, 113-126.

Zeckhauser, Richard (1981): "Preferred Policies When There is a Concern for Probability of Adoption", Journal of Environmental Economics and Management, 8, 215-237.

Appendix 1

We assume initially that all firms have the same level of emissions, y^*, before any control mechanism is implemented. There are two groups of firms, characterized by parameters ϕ_L and ϕ_H which correspond to different marginal abatement costs. Total abatement costs are taken to be quadratic, so the costs of reducing emissions from y^* to y are $\phi_J.(y^*-y)^2$, for $J = L,H$. For simplicity, these costs are taken to be observable by the local government.[1] Thus, marginal benefits from emissions are as shown in Figure 2.

The emission tax rate is t. Suppose the local authority can afford to inspect up to a fixed proportion p of the firms (i.e. it makes at most pn inspections, where n is the number of

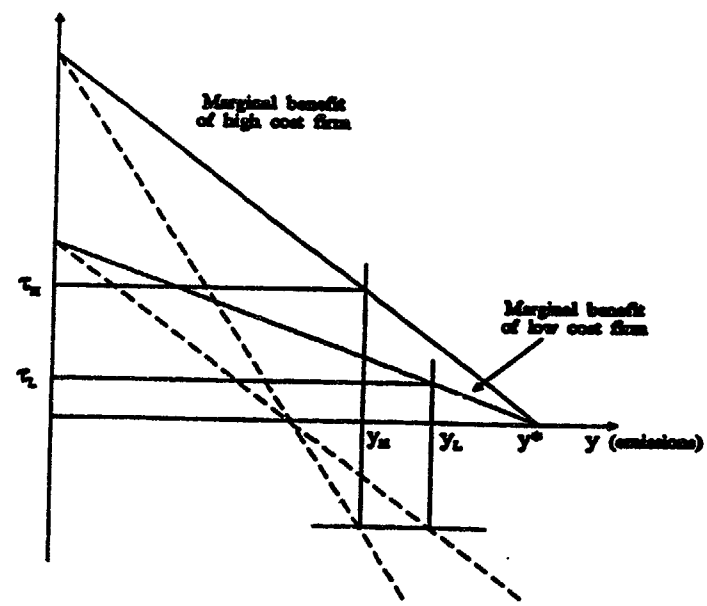

FIGURE A.1

[1]The results of the case of a tax are not qualitatively changed if a distribution of costs is assumed about each cost level, ϕ_J. When the enforcement of a quota is analyzed below, such a non-degenerate distribution will be assumed.

firms). Since it can observe the value of ϕ for each firm, it can inspect different proportions in each group, p_L and p_H. For a firm of type ϕ_j, the expected tax rate is then $\tau_j = p_j t$.[2]

The revenue obtained by the government is

$$R = n[\tau_L y(\phi_L, \tau_L) + \tau_H y(\phi_H, \tau_H)]$$

The local government then solves the program

$$\max_{\tau_L, \tau_H} R \quad s.t. \quad \tau_L + \tau_H \leq 2\tau$$

where $\tau = pt$ is fixed. If there was no constraint, the agency could choose τ_L and τ_H independently. Interpreting the firms' marginal benefit curves as demand for emissions curves, the government acts as a discriminating monopolist and sets marginal revenue from each type equal to zero (= marginal cost to local authority of "supplying" emissions). This will result in $\tau_H > \tau_L$ and $y_H = y_L$, where $y_j = y(\phi_j, \tau_j)$.

However, unless the tax rate t is high enough, the constraint will be binding (for a given p). In this case, the effective tax rates (τ_L and τ_H) must be lowered, keeping the marginal revenue from each group of firms equal. From Figure 2, this will again result in $\tau_L < \tau_H$, but now also $y_L > y_H$.

These results can be shown mathematically by forming the Lagrangean for the local authority:

$$\mathcal{L} = R - \lambda[\tau - (\tau_L + \tau_L)]$$

where $\lambda \geq 0$. Differentiation with respect to τ_j (J = L,H) then yields

---

[2]Firms are assumed risk neutral, so maximize expected profits.

$$n(y_J+\tau_J\frac{\partial y_J}{\partial \tau_J}) + \lambda \geq 0$$

with equality if λ is positive. Thus

$$y_L+\tau_L\frac{\partial y_L}{\partial \tau_L} = y_H+\tau_H\frac{\partial y_H}{\partial \tau_H}$$

when $\lambda > 0$, which is just the equal marginal revenue rule. Note also that if R^* is the maximized value of revenue, then

$$\frac{\partial R^*}{\partial p} = \lambda t .$$

If the marginal cost of inspections is c, then the cost of inspecting at a rate p is cnp, and the marginal cost of the inspection rate is $\gamma = cn$. Thus resources will be spent on nonitoring until $\lambda t = \gamma$, or $\lambda = \gamma/t$. In particular, for all finite values of the tax rate, t, $\lambda > 0$, and so $y_L > y_H$. This result continues to hold when marginal costs of inspection are increasing.[3]

How are the actions of the local authority determined when a quantity instrument is assigned by the federal government? First note that if each firm has one of two cost levels (labelled by ϕ_L and ϕ_H) which are observable to the local government, then a given enforcement policy will

[3]The result does require that the marginal revenue curves intersect at zero, as is the case we have analzyed (linear marginal abatement costs and identical pre-tax emission levels).

result in either zero or full compliance by the firms of each category. The optimization problem of the local authority is then ill-defined.[4]

It is more realistic to assume that the observation of ϕ gives the local government a signal of a firm's costs, and that its true costs of abatement are parameterized by $\phi + \epsilon$, where ϵ is unobservable and has a distribution f(.) on some bounded support, $[-\epsilon^0,\epsilon^0]$. Now suppose that a quota $\bar{y}$ is announced by the central government, with a fine s, independent of the size of the violation, to enforce it. The local government makes inspections and keeps all fine collections. If it observes ϕ, and its inspection rate for ϕ_j-firms is p_j, then the expected fine for a ϕ_j-firm is given by

$$\sigma_j = sp_j$$

The total costs of compliance for a firm with marginal costs characterized by $\phi_j+\epsilon$ are

$$B(y^*,\phi_j+\epsilon) - B(\bar{y},\phi_j+\epsilon)$$

where B(.,.) is the benefit function (the marginal version of which is shown in Figure 2). In the case of linear marginal benefits, this is just

$$(\phi_j+\epsilon)(y^*-\bar{y})^2$$

---

[4]There is no enforcement level which maximizes the local agency's revenue. As long as the probability of being inspected for a given category of firms is low enough, none of the firms comply. Thus it is optimal to increase the inspection rate. When this rate reaches some critical value, p^*, all firms comply (since they have the same costs) and so revenue is zero. There is thus no optimal inspection rate p.

and a given expected fine σ_j defines a value $\epsilon_j(\sigma_j)$ below which all ϕ_j-firms comply, and above which none do.[5] This critical value is given by

$$e_j = \frac{\sigma_j}{(y^*-\bar{y})^2} - \phi_j .$$

The revenue of the local agency is

$$R(e_L,e_H) = \sigma_L(e_L)[1-F(e_L)] + \sigma_H(e_H)[1-F(e_H)]$$

where $F'(.) = f(.)$, and $\sigma_j(\epsilon_j)$ is the inverse of the critical value function $\epsilon_j(.)$. Revenue is to be maximized subject to the local agency's enforcement budget constraint $\sigma_L + \sigma_H = 2\sigma$, where $\sigma = sp$ and p is the total number of inspections. Taking the total differential of the previous expression, we find

$$dR = [\sigma'_L(e_L)[1-F(e_L)] - \sigma_L(e_L)f(e_L)]de_L +$$
$$[\sigma'_H(e_H)[1-F(e_H)] - \sigma_H(e_H)f(e_H)]de_H$$

Now suppose the local authority adopts an inspection policy that results in equal compliance from both groups of firms; that is $\epsilon_L = \epsilon_H = \epsilon$. This will clearly require a higher rate of inspection of the high cost group than the low cost group, so that $\sigma_H(\epsilon) > \sigma_L(\epsilon)$. From the xpression for $\epsilon_j(\sigma_j)$ we

[5]We will assume that solutions are interior, so that there are always some firms that comply and some that don't in each cost group.

see that ϵ_i^* is independent of J . Therefore, a change $d\epsilon_L = -d\epsilon_H$ is feasible for the local authority.[6]

The change in revenue with this reallocation of enforcement resources is

$$dR = (\sigma_L'(\epsilon)-\sigma_H'(\epsilon))[1-F(\epsilon)]d\epsilon_L - (\sigma_L(\epsilon)-\sigma_H(\epsilon))f(\epsilon)d\epsilon_L$$

The first term is zero, so since $\sigma_H(\epsilon) > \sigma_L(\epsilon)$, the expression is positive. Therefore, it is optimal for the local authority to induce a higher rate of compliance from low cost firms than from high cost firms. For a given number of compliers - and hence a given level of abatement - this is strictly more efficient than equal compliance rates.

The general result stemming from this analysis is that in using a tax to attain a given level of abatement, most of the reduction in emissions is undertaken by high-cost firms (recall the result that $y_L > y_H$). However, when a quota is used, most of the reduction in emissions is done by low-cost firms.

This suggests that when the enforcement agency is a profit maximizer, the use of a quantity instrument may be preferred. However, this conclusion cannot be drawn immediately. The problem is that while more abatement is done by low cost firms in this case, some firms do no abatement. On the other hand, when a tax is used, all firms make some reduction in emissions. The relative size of total costs of abatement is thus not determined, and the model must be solved completely to ascertain which instrument is in fact the most efficient.

Also the decision of the agency about its budget has been brushed over - we assumed a fixed inspection budget, implying a fixed number of inspections. It is possible that when inspectors

---

[6]Since $\sigma_L + \sigma_H = \sigma$, $d\sigma = 0 = d\sigma_L + d\sigma_H$ for any feasible change in inspection policy (for a given enforcement budget). Thus we require $d\sigma_L = -d\sigma_H$. But $d\sigma_L = \sigma_L'(\epsilon)d\epsilon_L = -\sigma_H'(\epsilon)d\epsilon_H = -d\sigma_H$.

are financed nationally this assumption isn't too bad. It is very likely that some local administrations will not have the expertise and personnel to make a serious choice over aggregate inspection levels themselves.

APPENDIX 2 [1]

An intuitive explanation of the papers by Myerson and Satterthwaite (1983) and Crampton, Gibbons and Klemperer (1987) is presented. We consider the allocation of a single, indivisible object, to agents with privately known valuations.

The problem of allocating emission levels between two agents is different, if marginal costs and benefits are not constant, since the "object" - i.e. the total level of emissions - is split between them at the optimum. However, the same intuition carries over to that case.

Buyer and Seller

Consider a buyer and a seller with an object (belonging to the seller) to trade. They value the object at b and s respectively, independently and identically distributed uniformly on [0,1]. An efficient trading mechanism assigns the object to the buyer if and only if $b > s$.

Suppose the buyer's valuation, b, has been truthfully revealed. The seller then will either not sell (if $s > b$), or will demand a price b (if $s < b$), since she can claim that s is very close to (but less than) b. That is, to induce truthful revelation by the seller, given truthful revelation by the buyer, the seller must get all the consumer surplus, equal to b-s.

On the other hand, suppose the seller's valuation, s, is known to the buyer. The buyer will then either not buy (if $s > b$), or will pay a price s (if $s < b$), since it can claim b is very close to (but greater than) s. That is, to induce truthful revelation by the buyer, given truthful revelation by the seller, requires that the buyer gets all the consumer surplus.

Thus, each agent must receive the full consumer surplus, implying that efficient trade is possible only if an outside subsidy, equal to b-s, is available. (This corresponds to the requirement for an outside subsidy, B, in the test.) *Ex ante*, the expected value of the required subsidy is

---

[1] Thanks to Jeremy Bulow for helpful comments regarding this appendix.

$$E(b-s|b>s) = E(b/2 \,.\, b)$$
$$= E(b^2/2)$$
$$= 1/6 \,.$$

If the agents could be convinced to pay for the opportunity of using the trading mechanism, enough money might be raised to finance the required subsidy. But consider the buyer who values the object at just a little more than zero. It will not be willing to pay much to join the mechanism, because even if it receives the object, its gains from trade will be negligible. In this sense, the worst off buyer (with valuation equal to zero) will not pay to join the mechanism.

Similarly, the worst off seller - the one with valuation equal to one, and hence the least to gain from trading - will not be willing to pay for the use of the mechanism. Thus, since the worst off agents can't be induced to finance the subsidy, we cannot be assured, *ex ante*, of realizing efficient trades.

Distributed Property Rights

If each agent initially owns half the object, then efficiency requires the same *ex post* allocation as above. However now, each will be willing to pay to join the incentive compatible mechanism. If the valuations are v_1 and v_2 for agents 1 and 2 respectively, then the trading mechanism is:

$v_i > v_j \Rightarrow$ agent i gets the object and pays v_j; and agent j gets paid v_i.

The worst off agent now has $v_i = ½$. If $v_i > ½$, then agent i expects on average to be a buyer and make a positive profit. If $v_i < ½$, it expects to sell its share of the object, and make a profit also. If $v_i = ½$, it "expects to be neither".

But the worst off agents still expect to make a profit from the scheme. For example, if agent 1 values the object at ½, its expected profit is

$$\begin{aligned} & E(\tfrac{1}{2}-v_2 \mid v_2<\tfrac{1}{2}) + E(v_2-\tfrac{1}{2} \mid v_2>\tfrac{1}{2}) \\ &= p(v_2<\tfrac{1}{2}) \cdot \tfrac{1}{4} + p(v_2>\tfrac{1}{2}) \cdot \tfrac{1}{4} \\ &= \tfrac{1}{2} \cdot \tfrac{1}{4} + \tfrac{1}{2} \cdot \tfrac{1}{4} = \tfrac{1}{4} . \end{aligned}$$

Similarly for agent 2. Thus, the total amount that the worst off agents are willing to pay to join in the trading mechanism is ½. The expected value of consumer surplus, on the other hand, is

$$E(v_1-v_2 \mid v_1>v_2) + E(v_2-v_1 \mid v_1<v_2) = 1/6+1/6 = 1/3 .$$

Therefore, *ex ante*, the worst off agents (and hence any other traders) are willing to pay more than enough to finance the allocation mechanism (since 1/2 > 1/3).

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS871	The Distribution of the Benefits from Social Services in Indonesia, 1978-87	Dominique van de Walle	March 1992	A. Bhalla 37699
WPS872	Romania's Evolving Legal Framework for Private Sector Development	Cheryl W. Gray Rebecca J. Hanson Peter G. Ianachkov	March 1992	CECSE 37188
WPS873	Measure and Interpretation of Effective Protection in the Presence of High Capital Costs: Evidence from India	Francois M. Ettori	March 1992	F. Ettori 32340
WPS874	The Trade Restrictiveness Index: An Application to Mexican Agriculture	James E. Anderson Geoffrey Bannister	March 1992	G. Ilogon 33732
WPS875	Rural Finance in Developing Countries	Jacob Yaron	March 1992	C. Spooner 30464
WPS876	Old Debts and New Beginnings: A Policy Choice in Transitional Socialist Economies	Ross Levine David Scott	March 1992	W. Pitayatonakarn 37664
WPS877	Assessing Gains in Efficient Production Among China's Industrial Enterprises	Gary H. Jefferson Wenyi Xu	March 1992	CECSE 37188
WPS878	Adjustment and Private Investment in Kenya	Kazi M. Matin Bernard Wasow	March 1992	D. Ballantyne 37947
WPS879	Comprehensive Water Resources Management: A Concept Paper	Peter Rogers	March 1992	D. Ranger 31296
WPS880	Exchange Rate Policy, the Real Exchange Rate, and Inflation: Lessons from Latin America	Miguel A. Kiguel	April 1992	R. Luz 34303
WPS881	Dual and Multiple Exchange Rate Systems in Developing Countries: Some Empirical Evidence	Nita Ghei Miguel A. Kiguel	April 1992	R. Luz 34303
WPS882	Issues in Reforming Financial Systems in Eastern Europe: The Case of Bulgaria	Alfredo Thorne	April 1992	L. Ly 37352

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS883	Malaria: The Impact of Treated Bed-Nets on Childhood Mortality in the Gambia	Pedro L. Alonso Allan G. Hill Patricia H. David Greg Fegan Joanna R. M. Armstrong Andreas Francisco K. Cham Brian M. Greenwood	April 1992	O. Nadora 31091
WPS884	Intercommodity Price Transmittal: Analysis of Food Markets in Ghana	Harold Alderman	April 1992	C. Spooner 30464
WPS885	The Impact of EC-92 on Developing Countries' Trade: A Dissenting View	A. J. Hughes Hallett	April 1992	A. Kitson-Walters 33712
WPS886	Factors That Affect Short-Term Commercial Bank Lending to Developing Countries	Sudarshan Gooptu Maria Soledad Martinez Peria	April 1992	L. Dionne 31426
WPS887	Power Sharing and Pollution Control: Coordinating Policies Among Levels of Government	William Jack	April 1992	P. Pender 37851